

Sediment budget of Lake Tana and the role of lacustrine plains

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Abstract

Overbank sedimentation on river floodplains can result in a significant reduction of the suspended sediment load transported by a river and thus represents an important component of the catchment sediment budget. This study attempts to quantify the amount of sediment stored on the floodplains, transported to the lake, delivered out of the lake and stored into Lake Tana annually in order to establish a sediment budget for Lake Tana Basin, Ethiopia. In 2012 and 2013, suspended sediment concentration (SSC) and discharge measurements were made at 13 stations, of which the two are at lake outlets. Based on the land cover and rainfall seasonality, the yearly data have been divided into five periods and five different sediment rating curves were established for each of the 11 river monitoring stations. Mean monthly SSC was also calculated for the two outlets. The effects of the floodplain on river sediment load were investigated using the upstream and downstream sediment load observations of the Gilgel-Abay, Gumara, Rib and Megech Rivers. As a result, the gross annual sediment load transported to Lake Tana from both gauged and ungauged rivers was ca. 2.62 million tons, dominantly from Gilgel-Abay (29%) and Gumara (21%) catchments. Using the developed relationship of the annual sediment yield (SY) with catchment area and mean annual rainfall, ungauged rivers contribute 996,968 tons. This eye-catching figure is due to the absence of floodplains along the ungauged rivers. The result based on the upstream and downstream sediment observations also shows that 482,363 tons or 32 % of the gross sediment transported from rivers crossing the floodplains is deposited in the lacustrine plains annually. The lacustrine plain bordering Gumara River takes the lion share of total sediment deposited on floodplains (71%), likely due to having a meandering river that crosses a wide and low gradient lacustrine plain. This figure indicates that the lacustrine plain also serves as sink of sediment, which was softly touched in earlier studies. The analysis also revealed that ca. 1.09 million tons sediment annually leave the lake through the two outlets. The estimated annual sediment deposited in Lake Tana is about 1.04 million tones or 0.28 mm yr⁻¹ with a calculated suspended sediment trap efficiency (T_e) of 49%. Furthermore, SSC and sediment yield are generally lower towards the end of the rainy season than at the start for the same runoff discharge. The reason behind is that the soil in cultivated fields were bare and loose due to frequent ploughing and seedbed preparation at the beginning of the rainy season, as a result the level of SSC recorded is very high mostly in July and sometimes in August. Later on in the season, increased crop and vegetation cover leads to a decrease in the sediment supplies (exhaustion effect). Based on the established sediment budget and its calculated components, one

can conclude that the expected lifetime of Lake Tana is relatively higher than the output of earlier studies. In case bedload is also taken into account, T_e is even more, the lake is expected to fill up earlier, and the sediment budget is quite different.

Keywords: Sediment budget, Sedimentation, Floodplain, Lake Tana Basin